

REMARKS

The Final Office Action mailed December 30, 2005, has been received and reviewed. Claims 1 through 17, 19 through 29, 31 and 32 are currently pending in the application. Claims 1 through 17, 19 through 29, 31 and 32 stand rejected. Applicant proposes to amend claims 1 and 21. Reconsideration is respectfully requested.

35 U.S.C. § 102(b) Anticipation Rejections

Anticipation Rejection Based on U.S. Patent No. 5,904,565 to Nguyen et al.

Claims 1 and 6 through 8 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Nguyen et al. (U.S. Patent No. 5,904,565). Applicant respectfully traverses this rejection, as hereinafter set forth.

A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *Verdegaal Brothers v. Union Oil Co. of California*, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). The identical invention must be shown in as complete detail as is contained in the claim. *Richardson v. Suzuki Motor Co.*, 9 USPQ2d 1913, 1920 (Fed. Cir. 1989).

Nguyen discloses a method of forming a copper interconnection structure between levels in an integrated circuit. (Nguyen, col. 1, lines 7-12). Barrier layers are selectively formed in the integrated circuit to prevent copper contamination and are selectively etched to improve conductivity between copper levels in a via or damascene structure. (*Id.* at col. 3, lines 51-60). The integrated circuit includes a metal level and a dielectric interlevel. (*Id.* at col. 6, lines 1-3). A nonconductive barrier layer is formed over the dielectric interlevel. (*Id.* at col. 6, lines 5-7). An additional barrier layer is formed over sidewall surfaces of the dielectric interlevel, areas of the metal level, and a surface of the nonconductive barrier layer. (*Id.* at col. 6, lines 11-16). The additional barrier layer is selectively etched, by anisotropically etching, to remove the additional barrier layer over areas of the metal level and the surface of the nonconductive barrier layer. (*Id.* at col. 4, lines 10-14 and col. 6, lines 17-21). The additional barrier layer on the sidewall surfaces of the dielectric interlevel remains. (*Id.* at col. 6, lines 21-23). The additional barrier layer is formed from conductive and nonconductive materials. (*Id.* at col. 6, lines 11-16).

By way of contrast with Nguyen, claim 1 of the presently claimed invention recites a “method of forming a barrier layer on a surface of a semiconductor device structure, comprising: providing a semiconductor substrate; forming a dielectric layer over the semiconductor substrate, the dielectric layer having at least one trench; selectively depositing a metallization layer in the at least one trench; and forming a planar barrier layer overlying the metallization layer and the dielectric layer, the barrier layer comprising at least one conductive portion over the metallization layer and at least one nonconductive portion over the dielectric layer.”

Applicants respectfully submit Nguyen does not anticipate claim 1 because Nguyen does not expressly or inherently describe each and every element of the claim. Specifically, Nguyen does not expressly or inherently describe the element of “forming a planar barrier layer overlying the metallization layer and the dielectric layer, the barrier layer comprising at least one conductive portion over the metallization layer and at least one nonconductive portion over the dielectric layer.” While Nguyen discloses forming a barrier layer, Nguyen does not disclose that this barrier layer includes a conductive portion formed over a metallization layer and a nonconductive portion formed over a dielectric layer. Instead, Nguyen discloses that in some embodiments, the barrier layer is conductive and in other embodiments, the barrier layer is non-conductive. Nguyen provides examples of materials for either the conductive barrier layer or the non-conductive barrier layer. (Nguyen, col. 7, lines 40-60). However, Nguyen does not disclose that the barrier layer has conductive portion formed over a metallization layer and a nonconductive portion formed over a dielectric layer as recited in claim 1 of the presently claimed invention.

Additionally, Nguyen does not disclose “forming a planar barrier layer” as recited in claim 1 of the presently claimed invention. Instead, in FIG. 18, Nguyen discloses a horizontal non-conductive layer 190 and a vertical conductive layer 214. Such is not the presently claimed invention. Since Nguyen does not expressly or inherently describe each and every element of claim 1, the anticipation rejection is improper and should be withdrawn.

Claims 6-8 are allowable as depending, either directly or indirectly, from allowable claim 1.

Claim 8 is further allowable because Nguyen does not expressly or inherently describe

that a metal layer selected from the group consisting of titanium, zirconium, and hafnium is deposited over the metallization layer and the dielectric layer.

35 U.S.C. § 103(a) Obviousness Rejections

Obviousness Rejection Based on U.S. Patent No. 5,904,565 to Nguyen et al.

Claims 2 through 5, 9 through 17, 19 through 29, 31 and 32 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Nguyen et al. (U.S. Patent No. 5,904,565). Applicant respectfully traverses this rejection, as hereinafter set forth.

M.P.E.P. 706.02(j) sets forth the standard for a Section 103(a) rejection:

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or combine reference teachings. Second, there must be a reasonable expectation of success. Finally, **the prior art reference (or references when combined) must teach or suggest all the claim limitations.** The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). (Emphasis added).

The nonobviousness of independent claim 1 precludes a rejection of claims 2 through 5, 9 through 17, 19 and 20 which depend therefrom because a dependent claim is obvious only if the independent claim from which it depends is obvious. See *In re Fine*, 5 U.S.P.Q.2d 1596, 1600 (Fed. Cir. 1988), see also MPEP § 2143.03. Therefore, the Applicant requests that the Examiner withdraw the 35 U.S.C. § 103(a) obviousness rejection to independent claim 1 and claims claims 2 through 5, 9 through 17, 19 and 20 which depend therefrom.

Claim 3 is further allowable because Nguyen does not provide any teaching or suggestion to form the dielectric layer from a polymer selected from the group consisting of a foamed polymer, a fluorinated polymer, and a fluorinated-foamed polymer.

Claim 4 is further allowable because Nguyen does not provide any teaching or suggestion to form the dielectric layer from polyimide.

Claim 10 is further allowable because Nguyen does not provide any teaching or suggestion to deposit the metal layer by selecting an implant energy so that the metal layer

penetrates a surface of the metallization layer and the dielectric layer. Nothing in Nguyen teaches or suggests that a metal layer, which is to be formed into a barrier layer, penetrates a surface of the metallization layer and the dielectric layer.

Claim 11 is further allowable because Nguyen does not provide any teaching or suggestion to deposit the metal layer by selecting the implant energy to be from about 0.1 keV to about 2.0 keV so that the metal layer penetrates the surface of the metallization layer and the dielectric layer.

Claim 12 is further allowable because Nguyen does not provide any teaching or suggestion to select the implant energy so that the metal layer penetrates a depth of from about 5Å to about 50Å into the metallization layer and the dielectric layer.

Claim 13 is further allowable because Nguyen does not provide any teaching or suggestion to form the barrier layer by reacting at least a portion of the metal layer with nitrogen. Rather, the barrier layer of Nguyen is formed by a conformal deposition technique.

Claim 14 is further allowable because Nguyen does not provide any teaching or suggestion to form the barrier layer by exposing the metal layer to a nitrogen atmosphere.

Claim 15 is further allowable because Nguyen does not provide any teaching or suggestion to expose the metal layer to the nitrogen atmosphere for an amount of time sufficient to incorporate nitrogen into at least a portion of the metal layer.

Claim 16 is further allowable because Nguyen does not provide any teaching or suggestion to expose the metal layer to nitrogen, nitric oxide, nitrous oxide, or ammonia.

Claim 17 is further allowable because Nguyen does not provide any teaching or suggestion to expose the metal layer to a nitrogen plasma or a rapid thermal nitrogen treatment.

Claim 19 is further allowable because Nguyen does not provide any teaching or suggestion to form the conductive portion over the metallization layer by reacting nitrogen with a first portion of the barrier layer to form at least one metal nitride portion.

Claim 20 is further allowable because Nguyen does not provide any teaching or suggestion to form the nonconductive portion over the dielectric layer by reacting a second portion of the barrier layer with the dielectric layer to form at least one metal oxide portion, metal oxynitride portion, metal carbide portion, or metal carbonitride portion.

Nguyen also does not provide a motivation to produce the claimed invention. To provide a motivation or suggestion to combine, the prior art or the knowledge of a person of ordinary skill in the art must “suggest the desirability of the combination” or provide “an objective reason to combine the teachings of the references.” M.P.E.P. § 2143.01. The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *Id.* (emphasis in original). “[I]t is fundamental that rejections under 35 U.S.C. § 103 must be based on evidence.” *In re Lee*, 277 F.3d 1338, 1342 (Fed.Cir. 2002). This evidence “must be based on objective evidence of record” and can not be based on conclusory statements. *Id.* at 1343 and 1345.

The Examiner argues that the limitations recited in dependent claims 2-5, 9-17, 19, and 20 would be obvious to one of ordinary skill in the art because “Nguyen shows the method substantially as claimed” but “lacks anticipation only in not teaching the materials of the dielectric, methods and details of deposition of the metal layer by implantation; formation parameters associated with deposition of the barrier including nitrogen exposure.” Office Action of December 30, 2005, p. 4. The Examiner states that “[i]t would have been obvious to one of ordinary skill in the art to have taught the materials of the dielectric, methods and details of deposition of the metal layer by implantation; and, formation parameters associated with deposition of the barrier including nitrogen exposure, in the method of Nguyen, with the motivation that these associated parameters and deposition methods are conventional alternatives and produce equivalent quality devices.” *Id.*

However, this reasoning by the Examiner is conclusory and is not based on objective evidence of record. Nothing in Nguyen or in the knowledge generally available to one of ordinary skill in the art suggests the desirability of producing the claimed invention or provides an objective reason to produce the claimed invention. While Nguyen teaches forming a barrier layer, this barrier layer does not include a planar barrier layer having at least one conductive portion over a metallization layer and at least one nonconductive portion over a dielectric layer. As such, Nguyen does not provide any teaching or suggestion for forming a planar barrier layer that has at least one conductive portion over a metallization layer and at least one nonconductive portion over a dielectric layer.

Furthermore, nothing in Nguyen or in the knowledge generally available to one of ordinary skill in the art suggests the desirability of, or provides an objective reason for, forming a barrier layer by reacting a portion of a metal layer with nitrogen, such as by exposing a metal layer to a nitrogen atmosphere, as recited in the dependent claims. In fact, Nguyen teaches very few details on how its barrier layer is formed and only states that the barrier layer is deposited conformally. As such, the barrier layer of Nguyen appears to be deposited as a complete or finished layer. Therefore, this barrier layer is not formed by reacting a metal layer in a nitrogen atmosphere, as recited in dependent claims 7-17, 19, or 20.

Independent claim 21 recites a “method of forming a barrier layer on a surface of a semiconductor device structure, comprising: providing a semiconductor substrate; forming a dielectric layer over the semiconductor substrate, the dielectric layer having at least one trench; selectively depositing a metallization layer in the at least one trench; depositing a metal layer overlying the metallization layer and the dielectric layer; and exposing the metal layer to a nitrogen atmosphere to form a planar barrier layer overlying the metallization layer and the dielectric layer, the planar barrier layer comprising at least one conductive portion over the metallization layer and at least one nonconductive portion over the dielectric layer.”

Nguyen does not teach or suggest all of the limitations of claim 21 because Nguyen does not teach or suggest the limitation of “exposing the metal layer to a nitrogen atmosphere to form a barrier layer overlying the metallization layer and the dielectric layer, the barrier layer comprising at least one conductive portion over the metallization layer and at least one nonconductive portion over the dielectric layer.” Nothing in Nguyen teaches or suggests that its barrier layer is formed by exposing a metal layer to a nitrogen atmosphere. Rather, as previously discussed, Nguyen teaches very few details on how its barrier layer is formed, beyond that it is conformally deposited. The barrier layer of Nguyen appears to be formed as a complete layer and, therefore, is not formed by reacting a metal layer in a nitrogen atmosphere.

Nguyen also fails to teach or suggest “exposing the metal layer to a nitrogen atmosphere to form a planar barrier layer overlying the metallization layer and the dielectric layer, the planar barrier layer comprising at least one conductive portion over the metallization layer and at least one nonconductive portion over the dielectric layer” as recited in claim 21 of the presently

claimed invention. While Nguyen discloses forming a barrier layer, Nguyen does not teach or suggest that this barrier layer includes a conductive portion formed over a metallization layer and a nonconductive portion formed over a dielectric layer. Instead, Nguyen discloses that in some embodiments, the barrier layer is conductive and in other embodiments, the barrier layer is non-conductive. Nguyen provides examples of materials for either the conductive barrier layer or the non-conductive barrier layer. (Nguyen, col. 7, lines 40-60). However, Nguyen does not teach or suggest that the barrier layer has conductive portion formed over a metallization layer and a nonconductive portion formed over a dielectric layer as recited in claim 1 of the presently claimed invention.

Additionally, Nguyen does not teach or suggest “to form a planar barrier layer” as recited in claim 21 of the presently claimed invention. Instead, in FIG. 18, Nguyen discloses a horizontal non-conductive layer 190 and a vertical conductive layer 214. Such is not the presently claimed invention. Since Nguyen does not teach or suggest each and every element of claim 21, the obviousness rejection is improper and should be withdrawn.

In addition, there is no motivation to produce the invention of claim 21 for substantially the same reasons as discussed above for dependent claims 2-5, 9-17, 19, and 20. Since the cited reference does not teach or suggest all of the claim limitations and does not provide a motivation to produce the claimed invention, the obviousness rejection of claim 21 is improper and should be withdrawn.

Claims 22-32 are allowable as depending, either directly or indirectly, from an allowable claim 21.

Claim 24 is further allowable because Nguyen fails to teach or suggest depositing the metal layer overlying the metallization layer and the dielectric layer comprises selecting an implant energy so that the metal layer penetrates a surface of the metallization layer and the dielectric layer.

Claim 25 is further allowable because Nguyen fails to teach or suggest selecting the implant energy so that the metal layer penetrates the surface of the metallization layer and the dielectric layer comprises selecting the implant energy to be from about 0.1 keV to about 2.0 keV.

Claim 26 is further allowable because Nguyen fails to teach or suggest selecting an implant energy so that the metal layer penetrates a depth of from about 5Å to about 50Å into the metallization layer and the dielectric layer.

Claim 27 is further allowable because Nguyen fails to teach or suggest exposing the metal layer to the nitrogen atmosphere for an amount of time sufficient to incorporate nitrogen into at least a portion of the metal layer.

Claim 28 is further allowable because Nguyen fails to teach or suggest exposing the metal layer to nitrogen, nitric oxide, nitrous oxide, or ammonia.

Claim 29 is further allowable because Nguyen fails to teach or suggest exposing the metal layer to a nitrogen plasma or a rapid thermal nitrogen treatment.

Claim 31 is further allowable because Nguyen fails to teach or suggest reacting nitrogen with the metal layer to form at least one metal nitride portion of the barrier layer.

Claim 32 is further allowable because Nguyen fails to teach or suggest reacting the metal layer with the dielectric layer to form at least one metal oxide portion, metal oxynitride portion, metal carbide portion, or metal carbonitride portion of the barrier layer.

ENTRY OF AMENDMENTS

The proposed amendments to claims 1 and 21 above should be entered by the Examiner because the amendments are supported by the as-filed specification and drawings and do not add any new matter to the application. Further, the amendments do not raise new issues or require a further search. Finally, if the Examiner determines that the amendments do not place the application in condition for allowance, entry is respectfully requested upon filing of a Notice of Appeal herein.

CONCLUSION

Claims 1-17, 19-29, 31 and 32 are believed to be in condition for allowance, and an early notice thereof is respectfully solicited. Should the Office determine that additional issues remain which might be resolved by a telephone conference, the Examiner is respectfully invited to contact Applicant's undersigned attorney.

Respectfully submitted,



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